Spring 2010

Physics 137B: Problem Set #8
Due: 5PM Friday April 16 in the appropriate dropbox inside 251 LeConte (the "reading room")

Suggested Reading for this Week:

- B&J Section 12.3 (covered in class on Wed March 31)
- B&J Sections 13.1 to 13.3 (Note: we did not cover the material in Section 13.1 on on pages 590-592)

Homework Problems:

1. (Griffiths problem 6.19) Consider the eight $n = 2$ states $|2\ell m_j\rangle$. Find the energy of each state, under weak-field Zeeman splitting.

2. (Griffiths problem 6.21) Repeat the last problem under strong-field Zeeman splitting.

3. (from Griffiths Problem 11.2) We saw in class that the general solution to the Schrodinger Equation for a particle of given initial momentum $p = \hbar k\hat{z}$ scattering off a potential $V(r)$ is

$$\psi(r,\theta) = A\left\{e^{ikz} + f(\theta)\frac{e^{ikr}}{r}\right\}$$

for large r. Construct the analogs to this equation for one-dimensional and two-dimensional scattering.

4. (Modified from Liboff) We saw in class that $\mathcal{N}$, the number of particles per second scattering into a solid angle $d\Omega$ can be related to the incoming flux Φ (the number of particles per second per unit area of the incoming beam) differential cross section $d\sigma$:

$$\mathcal{N} = \Phi\frac{d\sigma}{d\Omega}d\Omega$$

and that the cross section for Rutherford scattering of a particle of charge q and energy E from a fixed charge Q is:

$$\frac{d\sigma}{d\Omega} = \left(\frac{qQ}{4E}\right)^2 \frac{1}{\sin^4(\theta/2)}$$

(a) Supposed our beam hits a target containing n scattering centers per unit area. What is the expression for the fraction of particles that scatter into the differential cone between θ and $\theta + d\theta$? Note: You may assume that each particle in the beam scatters from a single scattering center.

(b) Now, let's calculate what we would expect for Rutherford's experiment. Use the results from the previous part to find the fraction of α particles with incident energy 5 MeV which are scattered into a cone of width $d\theta$ at $\theta = \pi/2$ when passing through a gold sheet of thickness 1 μm. Note: gold has a density of 19.3 g/cm^3, $A = 197$ and $Z = 79$. You will need to use the fact that avogadro's number N_0 atoms of any atom has a mass of A grams.

5. Derive B&J equations 13.41, 13.42 and 13.43 from equation 13.40

6. Derive B&J equations 13.47 and 13.48 from 13.34, 13.35, 13.44 and 13.46.